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PERPETUAL MOTION.

By CHARLES E. BENHAM.

It seems at first sight a little extraordinary that science should insist upon the practical impossibility of the one phenomenon which is universal and constant, and more in evidence than any other in the whole universe.

From nebulae and suns down to atoms and electrons there is nothing but perpetual motion in every created thing, great and small—animal, vegetable, mineral, solid, liquid, gaseous, ethereal—and yet we are assured that perpetual motion is immutably barred by the law of the conservation of energy. It is well known that every molecule of the densest rocks of the globe is a congeries of rapidly vibrating atoms; that every particle of the ocean is similarly agitated in its component ultimates; that air and vapour particles dart incessantly with incredible and unceasing velocity through their appointed orbits; and that the all-permeating ether fulfils the "law of exchanges" in a ceaseless ripple of infinitesimal waves; and yet we are assured that perpetual motion is impossible. When we point to the incessant movements of rotation and revolution of the globe on which we live, and to the orbits of the very Sun and stars—to say nothing of the inner tremulations of their component atoms and electrons—we are told that all these things are but temporary; that they will "have their day, and cease to be"; that the mighty movements of these huge masses will ultimately ripple away in heat vibrations, and sink into a final repose of complete quiescence. When we ask for evidence of this tremendous surmise we are referred to the doctrine of the conservation of energy; in short, we are told that it must be so because perpetual motion is impossible. It seems very like arguing in a vicious circle. We start our proposition with the enunciation that perpetual motion is impossible; we turn to facts and find it in every particle of matter, and then we infer that all that movement must necessarily cease because perpetual motion is impossible. Q.E.D.

Perhaps it may be answered that some evidence of the decay of planetary motion is to be found in the life-history of our dead Moon, which has already so far altered that she is supposed to be no longer capable of supporting life; and we may be told of other observations of change in the province of astronomy, and also of calculations that have been made as to the past and future careers of suns and planets; but at best these are necessarily conjectures, founded for the most part on the assumption of the truth of the very point we are considering—the impossibility of perpetual motion. What is it, after all, but surmise that the Moon was once a world of life, and is now but a dead planet, or, even if that is granted, that she must gradually cease to revolve and rotate; and, *a fortiori*, what an enormous leap to assume positively that therefore even the Sun's great cycle of revolution will in aeons of time dwindle into inaction and repose; or, to take the other end of the scale, that every quivering molecule, atom, and electron is wearing itself out with its energies, and must one day sink down, tired out, in everlasting sleep? Considering that we have not even a glimmering knowledge of the causes of atomic or electronic vibration, or even of the more patent Brownian movements, that we can watch with our eyes under the microscope, what vanity it

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seems to dogmatise upon the causes that must finally arrest those inexplicable oscillations, and to assert positively that there is no possible replenishment of spent forces the origin of which we admit is beyond our investigation !

We may fully concede the truth of the doctrine, supported by abundant evidence, that all energy tends to ultimate in heat vibrations, and we may accept to the full the doctrine of the conservation of energy; but the case is not met by these admissions. Granted that all the forces of the universe tend to resolve themselves into undulations of heat, we have no assurance that they are not renewed; and, while their source and origin are inscrutable, we can claim no right to deny the possibility of their replenishment. The mystery of creation, if it implies anything, rather implies a possibility of re-creation than the opposite. While there are so many cosmic energies that have sources of origin that we have no means of exploring, we may justly keep an open mind as to the question of whether they may be capable of eternal replenishment. In so doing we do not in the least impugn the doctrine of the conservation of energy. We may be sure that from a purse that is being constantly opened the contents will gradually disappear, but we cannot say that the purse will become empty unless we know how and whence it is supplied, and whether the supplies are or are not inexhaustible.

In the same way, without disputing the calculated life-periods of the radio-actives, without denying that in time their energy may be expended, we must not hastily assume that all atomic and electronic motions will expire. It may be that there is a simultaneous replenishment provided for in the economy of the universe, making good the loss. In the recesses of ancient rocks have been found liquid films embedded in quartz, and containing minute particles of matter in suspension, which show under the microscope an activity of movement that has undoubtedly gone on for aeons of time before human or any life existed on this planet. What set them in notion we do not know, nor why they continue to move. Dare we presume to assert with any degree of confidence that these movements, the cause of which the wisest philosopher knows no more about than the child, must necessarily some day come to a standstill, because, forsooth, we have agreed among ourselves that it is impossible that they should do otherwise ? The philosophers of the Middle Ages used to reason that because it ought to be, therefore it is; which was very ridiculous. Some modern men of science sometimes argue that it cannot be, and therefore it is not; which is not much better.

The fact is that perpetual motion, in its widest sense, is far from proven to be impossible, and there is not even any reason why science should not one day discover means of enslaving the unflagging energies of nature in such a way as to produce an actual perpetual-motion machine of real practical value, and this without infringing any of the canons of orthodoxy. What is impossible is the unscientific attempt to arrive at perpetual motion by devices which overlook certain unknown and unquestionable laws of matter and force. It is impossible, for example, to construct a hydraulic ram which shall work in unceasing cycle by the force of the water which it itself has raised. It is impossible to make a wheel revolve by means of falling weights which shall themselves be raised with it to repeat the cycle. This type of quest for perpetual motion is the one that is based on pseudo-scientific principles, and carries its own condemnation; but it is different altogether in kind from that of which we are here speaking.

Yet so subtle are Nature's ways, and so delusive some of her paradoxes, that along this false track of pseudo-scientific research a whole procession of would-be discoverers has wandered restlessly for hundreds of years, wasting many lives and fortunes in the hopeless pursuit of the obviously unattainable. A fallacy is always latent in their devices, but Nature conceals it from their eyes with such whimsical spells that hundreds and thousands have been deceived by her cunning semblances, and lured on to seek what ever eludes them, and ever seems all but within their grasp.

It would be impossible in the scope of a short essay to outline even the principal examples of this futile province of fallacious research, nor would it be very profitable to do so, though the subject is not without its psychological interest, even if it is tedious to the better-informed mechanical expert, to whom the fallacies involved are patent at a glance. One early example may, however, be noticed as illustrating the long-lived character of this *ignis fatuus* of inventive genius.

As early as the year 1269 Peter Peregrinus wrote a famous epistle on the magnet in camp at the siege of Lucera. It is a wonderful fragment, whether we consider the uncongenial conditions under which it was written, or the really remarkable precision of the work. It is perhaps the first literary example of experimental scientific research, long anticipating that of those two pioneers of inductive science, William Gilberd and Francis Bacon. One flaw alone mars the truly scientific character of the little treatise — the last chapter, in which the writer takes up the quest for the *perpetuum mobile*, which he alludes to as a pursuit in which many had " wandered about wearied with manifold toil." This shows at least that the problem is one which has engaged attention from an early period. He attempts to solve the problem himself by a very simple device, in which a toothed iron wheel was to respond to a magnet in such wise that, after each tooth had been drawn to the loadstone, it went on a little way by its impetus, and was then subjected to repulsion from the magnet—it is not easy to see why—and

thus a continuous rotation of the wheel was to be secured. Needless to say, the machine was not ever made by Peregrinus, or he would have found out its futility. Its conception was founded on a fallacy which is perhaps the most common one in all the innumerable perpertual-motion devices—this reliance upon impetus to carry the movement over the crucial gap that always renders the cycle otherwise incomplete.

Delusive as the aims and hopes of the seekers after perpetual motion are, when the quest is based upon an attempt to circumvent the conservation of energy principle it is impossible to restrain sympathy with the tyro in science, who is misled into expectations of success; for the playful way in which Nature presents us with phenomena that sometimes seem as if they were cunningly devised to lure and entrap the human mind into a belief in the possibility of achieving this unattainable result by the simplest means is truly remarkable. These cynical snares of Dame Nature need not be detailed, but a typical example may be given to show how deceptive they may be. It is well known that water will rise, for some unaccountable reason (which we veil under the title of "capillary attraction"), to a considerable height above the level of the vessel containing it. A tube of the fiftieth of an inch in diameter will effect an ascent of an inch above the level of the water. Now, what more natural than to imagine that with the tubule protruding half an inch above the water the raised column would flow out at the top and back to the vessel, thus affording us a continual cycle of movement? Yet nothing of the sort happens. The liquid rises promptly to the top of the shortened tube, but there it remains, and shows no tendency to flow further. This is one of the whimsicalities of Nature which has led astray many a hopeful young explorer in the domain of physics, and the example is but one of many more that could be quoted in evidence of the tantalising lures which are presented in some of the paradoxical phenomena of science.

It may safely be said that the *perpetuum mobile* will never be found on lines that seek to circumvent the doctrine of the conservation of energy. Neither gravitation nor magnetism will every supply energy that will repair its own loss. But that is not to say that the perpetual-motion machine, based upon other principles altogether, is impossible.

Impossible of course it is, if we take into account the fact that the machine must itself wear out as time goes on. Even the most sanguine seekers after the self-moving machine were not blind to this qualification, but had their expectations been realisable in every particular except wear and tear it would be readily conceded that they had practically solved the problem. Their fallacies were quite apart from this factor, which by common consent need not be taken into account, because it is rather concerned with the perpetuity of the machine than that of its motion *per se*.

Waiving the inevitable wear and tear difficulty, is it possible that a *perpetuum mobile* could be established, and, if so, on what principles? The answer is that if the thing is to be done at all the motive power must depend upon the various forms of perpetual energy that do, as a matter of fact, exist all around us, to which allusion has already been made. We have but to harness these to our chariot and the problem is solved without the least transgression of the laws of Nature, for it is those laws that we shall call to our aid.

As a matter of fact, the problem has already been solved more than once, and by more than one device.

Strutt's so-called "radium clock" can hardly be quoted as an example, for this cannot be strictly called a perpetual-motion machine if the calculations which have fixed its extended life-period are to be trusted. According to these estimates it will have sacrificed half its energy in a couple of thousand years; but it must be remembered that this life-period is still but a theoretical computation, and, though probably reliable, is not, of course, proved experimentally as yet. Nature often belies the hypotheses of the philosophers, and we must wait a few centuries before we pronounce quite positively as to the decline of radio-active forces, however reasonable our expectation of it. The radium clock is of very simple construction. A leaf of aluminium foil is enclosed in a glass bulb, from which the air has, as far as possible, been exhausted, to prevent the "ionisation," which would render the experiment impracticable. Charged electrically by means of a small quantity of radium within the bulb, the aluminium leaf is repelled from its support until its free end stretches out far enough to make contact with an earthing plate, which discharges it, and the cycle recommences.

The electric dry pile is a close rival of the radium clock for prolonged electric activity. What its life-period may be it is impossible to say, and no attempt seems to have been made to dogmatise on the subject; but a celebrated example, made by Singer seventy-five years ago, has been continuously tinkling its little chime bell at Oxford for the whole of that long period of time; and though its vigour (for some unaccountable reason) occasionally varies, it shows no sign at present of any actual diminution of energy. And, minute as that energy must be per second, the amount which these tiny oscillations for seventy-five years without cessation represent would perhaps already make an appreciable total in foot-pounds, while the apparatus has by no means exhausted its store of latent potentiality.

But, apart from these mere approximations, the actual perpetual-motion machine—setting aside wear and tear of machinery—was practically accomplished many years ago, and the mechanism,

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of which full details are available, is one that could be reconstructed at any time.

The story of the original is an interesting one. In the latter half of the eighteenth century there was an ingenious jeweller in Shoe Lane named James Cox, and among the many marvellous contrivances of his genius was a clock, which was cleverly rendered self-winding by a barometer attachment arranged to actuate a cog-wheel in such a manner that, whether the mercury rose or fell, the wheel always revolved in the same direction, and kept the clock weight always wound up. Slight as the changes of atmospheric pressure occasionally are, Cox's difficulty was not by any means their insufficiency to keep pace with the descending clock weight. On the contrary, the chief trouble was to guard against overwinding. This was ingeniously obviated by a device which caused the cog-wheel to throw itself out of gear when the weight was nearly wound to the top.

Cox's museum in London, where this surprising mechanism was exhibited, together with many other ingenious contrivances, was a treasure-house of fascinating wonders. Some of his other marvels of workmanship will be found described in the "Annual Register" for 1765. In 1773 Cox obtained Royal Assent to an Act of Parliament enabling him to dispose of his museum. His clock was introduced the following year, but he was very chary of making public the details of its construction, contenting himself with vague generalities about the "philosophical and mechanical principles" on which it was based, and the clock remained a mystery to the public until James Ferguson, after a close inspection, openly divulged the secret, at the same time testifying, in a signed memorandum, as follows :—

> "I have examined the above-described clock, which is kept constantly going by the rising and falling of quicksilver in a most extraordinary barometer, and there is no danger of its ever failing to go, for there is always such a quantity of moving power accumulated as would keep the clock going for a year, even if the barometer should be taken quite away from it; and, indeed, on examining the whole contrivance and construction, I must with truth say that it is the most ingenious piece of mechanism I ever saw in my life.
>
> "JAMES FERGUSON.
>
> "Bolt Court, Fleet Street.
> *January 28th*, 1774."

Hardly less remarkable than the clock itself is the dramatic sequel of its subsequent history, incidentally brought to light in a work, entitled "Travels in China," by John Barrow, private secretary to Earl Macartney. From this volume it appears that among the presents "carried by the late Dutch Ambassador" were two grand pieces of mechanism from the Cox Museum, one of which was the perpetual clock. In the course of the long journey of the Dutch Embassy from Canton to Pekin both machines suffered some slight damage, and an endeavour was made to have them repaired at Pekin. On leaving the capital, however, it was discovered that the wily Chinese Prime Minister, Ho-tchang-tong, had taken a fancy to the wonderful timepiece, and had substituted an ordinary clock in its place. It was believed that he purloined the instrument with a view to ingratiating himself by making a personal gift of it to his emperor. Whether it ever reached the Imperial Palace can now never be known, for there is no light upon its subsequent history. Possibly it is still patiently recording the passing hours somewhere in China; possibly it has returned with other loot to London, and reposes as a Chinese antique in some marine store dealer's warehouse in the metropolis. Happily the exact and detailed drawings and the descriptions made by James Ferguson still exist, so that a replica could easily be made.

About the same period a perpetual clock was exhibited in Paris, which was similarly devised, except that the self-winding was effected by thermometric instead of barometric means. The expansion of a silver rod with the diurnal rise of temperature was employed, and it is said that seven or eight degrees of difference in temperature per day sufficed to keep the clock fully wound. Instances of kindred contrivances could be multiplied.

Of the greater powers of the universe, which seem available as perpetual servants of man, the three most important are the incessant variations of atmospheric pressure, the constant changes of temperature, and the unending sway of the ocean tides. These are all of them mighty storehouses of practically unbounded energy, and all the problem that rests with man is the harnessing of them for his purposes.

The most amenable of the three would seem to be the tidal ebb and flow. Round the shores of this island is more than enough power—running to waste, as it were, year in, year out—to produce all the lighting and motive energy required for the whole of our industrial enterprises. The fact has been frequently referred to by some of our most distinguished men of science, but the problem still awaits practical solution. Within a century or two it will almost certainly have been solved, and with it a new era of economy will commence.

In speaking of the tides as a perpetual source of energy, we must not, of course, forget that, according to prevailing theories, they, too, are destined to cease, and with their cessation is predicted a slackening of the rotation of the Earth itself. The friction of the tides, we are told, is gradually diminishing the speed of the Earth's daily rotation, and will go on doing so until our days, like those of the Moon, are twenty-eight times their present length, and our globe will be exposed to alternations

of about six hundred and seventy-two hours of sunshine and six hundred and seventy-two hours of darkness. All life will disappear, all vegetation will be destroyed, and the evaporated oceans will reveal the awful tragedies of their depths—the "Titanics," the "Lusitanias," and many another crime or disaster of the high seas. The Moon, it is surmised, has already passed through this ordeal. The tidal influence of our greater globe has won the primary victory against the satellite, and only time will achieve the Nemesis of lunar reprisal. All this is plausible enough conjecture, but in the technical sense it still remains "hypothesis" rather than "theory." It is founded upon the assumption that the energies of the universe are incapable of replenishment—a fundamental postulate which is far from being demonstrated—and until it is, we are fully justified in looking at tidal energy as a *perpetuum mobile*. Even with that far-off ultimate vision of "the wars of elements, the wreck of matter, and the crush of worlds," the ebb and flow of the ocean still remain for all practical purposes a source of perpetual energy.

But, while these huge forces are those to which attention is most naturally directed in our quest for an unfailing supply of power, the lesser movements of palpitating nature are not to be despised. What they lack in individual might the infinitesimals make up for in the prodigious number of their energy-bearing units.

To take one example only, the Brownian movement already briefly referred to. The term by which it is popularly known has a misleading suggestion of some social settlement scheme, and it is more scientifically named "pedesis," the original name of Brownian movement being merely a title associated with the discoverer, Dr. Robert Brown, who first observed it, about 1827, in the case of the minute contents of pollen grains, which he found when microscopically examined in a liquid menstruum were in a state of perpetual rotary and oscillatory, as well as even translatory movement, looking for all the world as if they were alive. That it is not life as we understand the term is clear from the fact that the movement is common to small particles of any substance, and it perseveres unaffected by vacuum, hermetical sealing, boiling, or any of the life-destroying conditions; while, as already stated, there are good geological evidences that it can keep up its energy for the countless millions of years that separate us from the early epochs of the world's history.

One of the most fascinating ways of preserving the phenomenon is to rub up a little gamboge (a gum resin which breaks up in water into exceedingly minute round particles). Dipping a fine flattened capillary glass tube into the solution a thin layer of it is drawn in. The tubule has its two ends hermetically sealed by momentary application of flame, and is then mounted in Canada balsam, and viewed as a microscopic object. Under a power of not less than a quarter-inch objective, the circling dance within the watery glass prism is beautifully seen; and, if only the slide is kept safe from German bombs and other dangers of this mad age, it may be taken from the cabinet at leisure every century or so and re-examined, without exhibiting any apparent diminution in the play of movement.

Any other minute particles may be similarly treated, and will give similar effects, with modifications according to the specific gravity of the particles and the nature of the liquid employed. It is theorised that electricity has some share in the phenomenon from the fact that substances which increase the conductive power of water (salts and acids) are said to diminish the rate of movement; while gum and other substances that decrease the conductive power accelerate the particles. But this is not confirmed by all experimenters, and of the cause and origin of pedesis no man knows anything with certainty.

Three principal theories—all mutually contradictory—have been put forward to explain the Brownian movement. The electric theory has little evidence in its support, and, in any case, does not go far to elucidate the mystery. A theory of "thermo-dynamic origin of the Brownian motions" was published in *The Monthly Microscopical Journal* of July, 1877, by the Rev. Joseph Desaulx, S.J., and seems plausible. It attributes the movements to the molecular vibrations which constitute heat. In the case of minute gas bubbles it is supposed that their minuteness enables the pressure of the molecules to vary upon the different points of their envelope. In the case of solid particles it is suggested that the molecules of the liquid in which they are suspended are bombarding them irregularly with force sufficient to cause them to oscillate, and calculations are given showing that the dimensions of the particles and the length of the molecules' path are appropriate to the fulfilment of the theory. In the same number of *The Journal* is a different theory altogether, by W. N. Hartley, F.R.S.E., who attributes the movement to variations in surface tension consequent upon variations in temperature of the surrounding liquid. This theory also appears to be confirmed by the experiments quoted by the author, but it fails to explain the fact that the movement is active in cases where there is no liquid, such as smoke particles in air. On the whole, Desaulx's hypothesis seems the most reasonable, though, of course, it still leaves unsolved the mystery of the perpetuity of movement, merely transferring it from the solid particles to the molecules of the liquid.

Still, the phenomenon itself is indisputable, and the practical possibilities of even such infinitesimal energies as these are not so contemptible as they

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might seem to be when we consider the trillions of combined activities which even an ounce bottle of gamboge solution may comprise; and, further, the enduring character of the movement. If time be taken into account, there may be measurable foot-pounds of energy represented in the expenditure of even those few tiny geological captives which have been beating the quartz walls of their cells since the days when the primaeval rocks were formed.

Professor Ames, of Johns Hopkins University, in Baltimore, amuses himself and his audience by an annual experiment, which may give us a hint of what our gamboge particles might do for the world if only they were properly trained and marshalled. His experiment consists in making a pailful of water boil from the heat generated in it by stirring it with a wooden paddle. Surprising as it may seem, the water by this simple expedient is actually raised to boiling-point by a continuous paddling executed by the Professor's assistants (working in shifts) for a period of five consecutive hours—a tedious experiment, but it comes off successfully.

This may give us a suggestion as to what we are justified in calling upon our gamboge particles to perform for us. Each little unit, no doubt, is a sorry worker considered singly, but each contributes its infinitesimally tiny share towards heating the water in which it performs its gyrations; and when we multiply this effect by billions upon billions the total in course of time may be not inconsiderable.

"Once nought is nought," reasoned the schoolboy; "twice nought is nought; three times nought—must be something—stick it down a one." It was faulty arithmetic, but there was a vestige of common sense even in this fallacious calculation. Once what seems like nought may also seem like nothing, but thousands of billions of times that inappreciable fraction of heat may mount up to the perceptible. A single degree of heat gained is full of significance and potential importance. An unfailing heat supply is an unfailing source of energy, and our pedesis may have in it possibilities of high practical value when the patient toil of men of science is devoted to the exploration of means to entrap and enslave the wasted activity of the infra-world.

THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION, MANCHESTER, 1915.

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THE second subject for discussion, namely," Colour Standards," put forward by the British Mycological Society, was introduced by Mr. J. Ramsbottom in the following paper :—

COLOUR STANDARDS.

During the past ten years there have been published three schemes of colours: Oberthür and Dauthenay's "Répertoire de Couleurs," Klincksieck and Valette's "Code des Couleurs," and Ridgway's "Color Standards and Color Nomenclature." These three works have been adopted by different naturalists, and it has seemed to the British Mycological Society that the question of a colour standard is one that might profitably be brought to the notice of the Affiliated Societies of the British Association.

As everyone who has had to deal with colour in the natural sciences realises, there are two fundamental difficulties: (1) the difficulty of understanding what is intended by any colour term used in a description; (2) the difficulty which any worker himself has of satisfactorily naming the colours in a species under discussion.

It is obvious that these difficulties have not come forward suddenly during the present century, and in the few days at my disposal I have attempted to trace out various previous attempts to get over the difficulty. In this way it would appear that the requisites of a standard could best be appreciated.

The earliest effort to define colours from the naturalist's standpoint to which I have found a reference is in an Appendix to Charleton's "De Nominibus Animalium," 1677. This author realises the almost infinite varieties of colours, and the difficulty of translating classical names into English idiom. He divides the colours up into groups: white, black, yellow, blue, and so on. He gives Latin names for the colours, e.g., *Psittaceus* is described as "Poppin-jay-green, such as the green of parrats, which in old English were call'd Pope-jayes, quasi Priests-jayes." This method of describing colour by referring it to some natural object has always been common with men of science, and has much to commend it. When one gets away from common objects, however, in the definition of colour obvious objections arise. The more perfect the scheme in any branch of science, the more difficult is it of general application.

The alternative method is to have samples of colour for comparison. It is to such scales we must look if we are to have a satisfactory scheme of denoting colours. Such colour charts have been brought forward at different times. The first colour chart of this description appears to have been published in Haynes' "Termini Botanici Iconibus Illustrati," 1807. There are thirty-six samples of colour which have Latin names appended. In the text the terms are explained, with examples where possible, and the German equivalent given. Next Werner's "Nomenclature of Colours," as introduced by Patrick Syme, was published in 1814; a second edition of this work was published seven years later. The first edition has one hundred and eight tints; the second one hundred and ten. The introduction gives the method by which each colour was prepared. The samples are very small (half-inch square), and pasted ten on a page. The name of the colour is given, and examples of the colour where possible from the animal, vegetable, and mineral kingdoms. Thus: *Wine yellow*; body of silk moth; stamina of honeysuckle; pale Brazilian topaz. Most of the colours have by this time considerably altered, and, on comparing the two editions, it is seen that many of the colours, with the same names, are quite different. This scheme met with some success, and was used in Barton's "Flora of North America," 1821.

In 1815 Mirbel, in his "Élémens de Botanique," gave a chart of eighty-three tints, the only explanation given being a naïve statement that by its aid any colour whatever can be matched; a statement which appears particularly ridiculous now that all the whites have turned black.

Another scheme which may be mentioned is that of Haytor, which is appended to Sinclair's "Hortus Ericaeus Woburnensis," 1825, one of the well-known Woburn monographs. An account of the origin of the scheme is given in a letter by Haytor to the Duke of Bedford. Sinclair had "lamented much that no work existed to render clear and definite all communications on the subject of any new or rare bloom. . . . In attempting at present to describe the colour of any given flower, the term *red*, he remarked, was applied to so many blossoms that it was impossible to define precisely what was meant by it; and, to give me an evidence of the want he complained of, he took me to several flowers, generally called *red*, but varying so much that, to my eye as a painter, they each demanded a different appellation for their colour." He adds that matters are made worse by adding the termination *-ish*, and arriving at such indefinite but common terms as "reddish" and "greenish." A comparison of the colour descriptions of the same varieties in present-day florists' catalogues shows clearly that matters are quite as bad as a hundred years ago; and the entomologist's *testaceus* and the mycologist's *ferrugineus* show that Latin terms are used with just as much levity. In Haytor's scheme two hundred and seventy two tints are arranged in a circle in the form of a mariner's compass, and the nomenclature is also nautical, *e.g.*, red, red by purple. Two gradations are appended, one showing the range from black to white, the other from brown to white. The scheme does not appear to have been at all successful.

Another arrangement of general application is that of Hay, "A Nomenclature of Colours applicable to the Arts and Natural Sciences, to Manufacturers, and other purposes of General Utility," 1845. The second edition has forty plates, each with six one and a half-inch-sided triangles of colour pasted in. The samples were very evenly painted, and very little fading appears to have taken place. The introduction gives the author's theories of colour, and the arrangement, which is difficult to follow, is based upon these. The nomenclature, in which "tempered green hue" and such like appear, was also probably a factor against any general adoption by naturalists.

Before this time Chevreul, Directeur des Ceintures à la Manufacture Nationale des Gobelins—the national manufactory of tapestry in Paris—began to devise a classification of colours. His first discussion, "La Loi du Contraste simultané des Couleurs," appeared in 1839. A full account of his scheme, and its application, is given in a memoir of nine hundred and forty-four pages (*Mém. Acad. Sci.*, Paris, 1861, "Exposé d'un Moyen de définir et de nommer les Couleurs"). This method, which it would take too long to describe, is still used at the national manufactory of tapestry, and is the basis of the modern French colour schemes. Theoretically, over fourteen thousand different colours, tones, shades, and tints are obtainable, but in practice a much smaller number suffices. In 1855 Digeon published a set of ten charts, "Cercles Chromatiques de M. E. Chevreul." The circles are divided into seventy-two sectors, and there is a gradual gradation from red through orange red to orange, and so on. The charts have different percentages of black added, from ·1 to ·9. Thus there are seven hundred and twenty different shades. The name of the colour is denoted by giving the number of the chart and of the sector. Chevreul's full scheme is made more complete by having different intensities of colour.

Radde's "Internationale Farben Skala," 1877, consists of fifteen cards. The first gives the forty-two cardinal tones of the arrangement; the remainder gives the range of these from *a* to *v*, thus comprising about eight hundred tints. A sliding block permits of the isolation of adjoining colours. The cards are inconvenient to use: the colours are printed on inferior paper, and are without names. The scheme has been used by mineralogists.

Since this date many different colour schemes have appeared, some of which have been drawn up without any reference to previous attempts, and have repeated faults which otherwise might have been guarded against. In 1886 appeared the book which has been most used until recent years, Ridgway's "A Nomenclature of Colors for Naturalists, and Compendium of Useful Knowledge for Ornithologists." Two of Ridgway's statements are much to the point. "Popular and even technical natural history demands a nomenclature which shall give a standard for the numerous hues, tints, and shades which are currently adopted, and now form part of the language of descriptive natural history." Again: "Popular nomenclature of colors has of late years, especially since the introduction of aniline dyes and pigments, become involved in almost chaotic confusion through the coinage of a multitude of new names, many of them synonymous, and still more of them vague or variable in their meaning. These new names are far too numerous to be of any practical utility, even were each one identifiable with a particular fixed tint." In this book there are one hundred and eighty-six named colours painted into rectangles 1-inch × ½-inch. The colours in the copies of this book which I have examined are not nearly so even as in Hay's book, or in the more recent works. Passing on we come to Saccardo's "Chromotaxia" of fifty samples, with a polyglot nomenclature. This appeared in 1891. In this year also a series of forty colours was given in Costantin and Dufour's "Nouvelle Flore des Champignons" to illustrate the terms used in the descriptions and the symbols in the drawings of fungi.

"A Chart of Correct Colors of Flowers" appeared in *The American Florist* for 1895. This was arranged by Matthews, and consisted of a single sheet with thirty-six squares of colour, with a very simple nomenclature.

Another American horticultural chart appeared about 1900 with the title, "Color Guide for Florists." This was arranged by Kohn, and contains one hundred and forty colour shades. A scheme which has been used by some naturalists is "The Prang Standard of Color." This contains one thousand one hundred and fifty-two examples, and is remarkable for its cheapness, costing only fifty cents. Unfortunately the colours are not named.

The "Répertoire de Couleurs"* of Oberthür and Dauthenay, published by the French Chrysanthemum Society in 1905, contains over one thousand four hundred samples. The colours are named in almost every case in several languages. The great objection to this work is its size.

The "Code des Couleurs"* of Klincksieck and Valette appeared in 1908. It is a convenient little book, containing seven hundred and twenty specimens of colour, but they are merely numbered. The work was prepared principally for the use of mycologists. Both the Répertoire and the Code are arranged on a simplification of Chevreul's method.

Ridgway's "Color Standards and Color Nomenclature"* was issued in 1912. The one thousand one hundred and fifteen samples are named, though some of the names are not such that would appear suitable for a standard nomenclature.

Added to these numerous charts are those of different manufacturers and those drawn up by artists, and so on. Even philatelists have their colour schemes.

Lovibund's tintometer is far too complicated and too expensive for ordinary use in the description of specimens. The fact that so many attempts have been made to draw up colour schemes shows clearly that a standard of colours is necessary, as is also a standard of nomenclature. Naturalists could decide to adopt the French Chrysanthemum Book or Ridgway. The former was adopted by the Royal Horticultural Society, but recently it has been somewhat ousted amongst horticulturists by the American book, principally owing to the latter being much more convenient to use. On enquiry I find that amongst naturalists these two works are the most frequently used.

The "Code des Couleurs," though very convenient to use, suffers from the fact that the colours are *unnamed*.

* Copies of these works were shown at the meeting.

XUM

But the Chrysanthemum Book costs a guinea and Ridgway thirty-five shillings! In most branches of science, colour is not regarded with so much favour as to demand such an outlay, even for a satisfactory range of tints. Colour in many organisms varies so much under different conditions that it is not regarded as a specific character. What seems to be required is, not a scale to record the minutest variation, but merely one that will add definiteness to the description of the general range in colour. Probably a scale with about two hundred samples would be found sufficient for ordinary use. In such branches of science as horticulture, mycology, ornithology, and so on, where colour is of more importance, additional colours could be interpolated. If anyone interested in any particular science will look through the colour charts which are here, he will find very many colours which will seem more or less useless in that science, and in certain cases will find that there are not sufficient of certain grades. As an example of what I mean: Horticulturists could dispense with a large number of the colours given in Ridgway; mycologists certainly can omit page after page. On the other hand, there is already a movement on foot to produce another edition of Ridgway, with more tones, of such colours as "salmon-pink." My own opinion is that it is not wise to attempt to make such a complete range as would satisfy every possible use. The way out of the difficulty is obviously that of having a general scheme with a small number of colours; then additional editions may be provided in those subjects where there is special demand, or separate sheets of the variations of the original colours of the general scheme could be prepared. If, as one would hope, a standard of colours should be adopted in all branches of science, art, and industry, the latter scheme would appear to be the most feasible. The advantages of having a universal standard of colours are so obvious that one would expect the very great difficulties of obtaining such would not prove insurmountable if the matter be approached in a proper manner.

The earlier schemes lacked one of the primary essentials of colour standards in that they were not standards at all. Ridgway's scheme is the only one in which the colours have been standardised by physical methods, and hence the only one in which the colours can be reproduced with accuracy. In the suggested standard of colours, it would be the work of physicists, by means of such apparatus as Michelin's grating and Maxwell's disc, to give us the definition of our colours. In this way the defect from which all colours suffer to some extent, *i.e.*, fading, could be brought to its lowest terms of inconvenience, though the samples of colour published would be made in such a way that fading would be guarded against as far as modern colour chemistry makes it possible.

The colours in the primary scheme should be named. No sane naturalist wishes to talk in such symbols as "4OJ8t." On the other hand, the same naturalist would not wish to use many of the colour terms, even in Ridgway, who rightly objects to such absurd names as "ashes of roses" and "elephant's breath." The usual method of assigning colours to common natural objects should be followed, as far as is possible, in the primary scheme. Whether in the more complicated schemes every colour, shade, tint, and hue should receive a name is one for consideration. I am informed that the colours supplied to artists under the same name are not always the same even from the same firm. This is ridiculous, if a colour name means anything. A standard of colours would seem to give some protection.

Unfortunately, most of us suffer from the fact that we have received no colour education. This has probably been one of the principal reasons why many people have not adopted a colour chart: the constituents of a given colour are not appreciated, and hence the difficulty of matching it. More attention seems to be paid to this subject in America than in this country, judging from the literature on the subject.

A further point is that a colour standard should be cheap. Charts of colour samples are supplied gratis by every dealer in artists' colours, wall distempers, and so on; yet the naturalist has to expend a considerable sum for a scheme, eighty per cent. of which is probably useless to him, and other workers in his subject may be using other charts. There seems no apparent reason why a suitable series of standard colours should not be published at a shilling or so. There is no need for much letterpress dealing with the theory of colour, but a few notes on the best way of comparing colours, having regard to texture of surface and various optical illusions. To summarise:—

1. For ordinary use there should not be too many colours.
2. A fair-sized, even sample of colour should be given.
3. The colour must be as durable as can be obtained.
4. The colour must be standardised by modern physical and chemical methods.
5. Colours to be interpolated in the special cases where necessary.
6. The colours must be named in the primary list, popular names being used where possible, and common objects referred to when suitable. If an international scheme be adopted, there would necessarily be a polyglot nomenclature.
7. The standard must be cheap, well arranged, and in book form.

In conclusion I would express my thanks to the numerous naturalists with whom I have discussed the question of a colour standard.

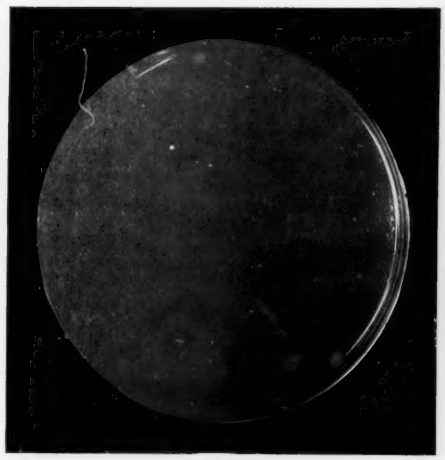
During the discussion which followed it was pointed out that there was an important commercial aspect to the subject, and it was the general opinion that, as the matter did not come within the province of any one of the Sections of the British Association, it should be referred to the Corresponding Societies Committee.

CLEAN MILK.

DETAILS of the steps which are to be taken by the National Clean Milk Society to raise the hygienic standard of milk have been published, and one of them is to call the attention of consumers to the necessity of guarding milk and milk products from contamination in the home. The very much more important need of making the producer obtain his milk as nearly biologically clean as is possible, though no doubt borne in mind, is not specifically mentioned. The photographs, of which reproductions are given in Figures 293–300, are from bacteriological culture dishes, which illustrate the methods of obtaining clean milk. The first four show the advisability of milking in the open air. Figure 293 gives the number of germs (each has developed into a colony, which is visible) that fell on the dish when it was exposed for a minute in a field. Figures 294 and 295 are for comparison, and show the results of a similar exposure in a cowhouse, firstly, under ordinary conditions, and, secondly, after hay had been moved about. Figure 296 shows what happened when some splashes flew from the milker's hands on to the culture dish, and tells its own tale. The need of discarding the first milk drawn from the teat is emphasised by Figure 297. The number of germs one hour after milking in a cubic centimetre of milk drawn into a sterilised flask is shown in Figure 298. A similar culture made after the milk had been kept for twenty-four hours is reproduced in Figure 299, while for further comparison a culture is given (see Figure 300) which was made from a cubic centimetre of milk taken from the tea table.

WILFRED MARK WEBB.

XUM



FIGUKE 293.

A culture showing the number of germs which fell on a dish exposed for one minute in a field.

FIGURE 294.

A culture showing the number of germs which fell on a dish exposed for one minute in a cowshed.

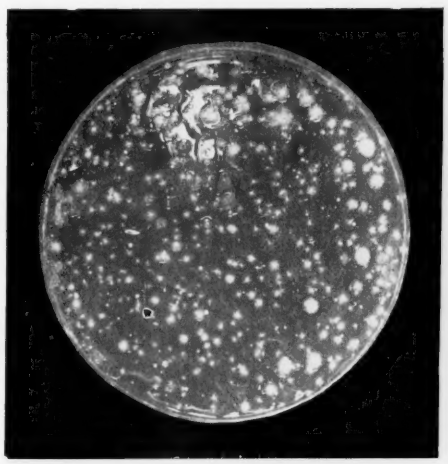


FIGURE 295.

A similar culture made after hay had been shaken in the stalls. An experiment illustrating the advantage of milking out of doors.

FIGURE 296.

A culture showing contaminations from the milker. The patches on the dish are where the splashes fell from the hands of the latter.

In all the experiments of which the results are given here, sterilised dishes containing nutrient gelatine were exposed, and afterwards kept at a suitable temperature. Each germ that fell on the surface of the jelly has developed into a colony which is visible to the naked eye.

XUM

FIGURE 297.

An experiment showing the advisability of rejecting the milk first drawn from the teat. This culture was made from such milk.

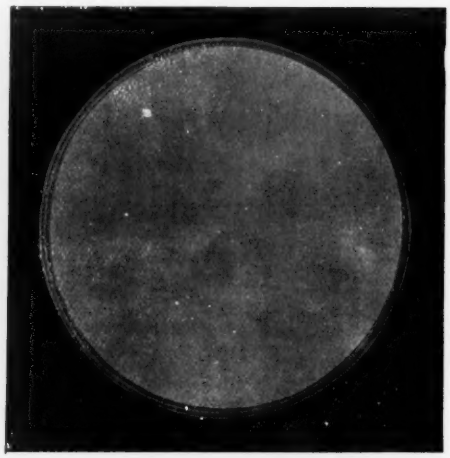


FIGURE 298.

The growths from a cubic centimetre of milk (taken under biologically clean conditions) one hour after milking.

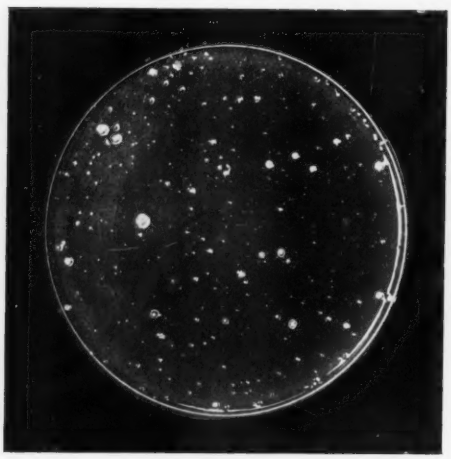


FIGURE 299.

A culture from milk used in the last experiment (see Figure 298), but which had been kept for twenty-four hours at a summer temperature.

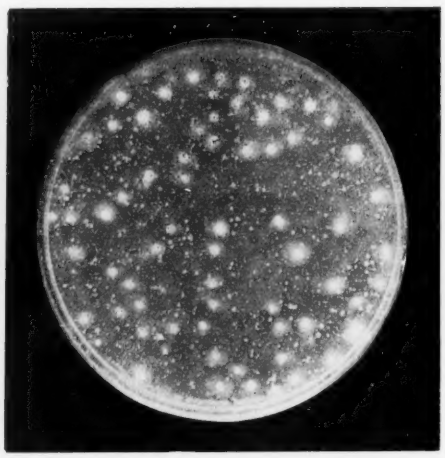


FIGURE 300.

A culture showing the number of germs which were in a cubic centimetre of milk taken in the ordinary way from a tea table.

THE FACE OF THE SKY FOR JANUARY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 62.

Date.	Sun.		Moon.		Mercury.		Venus.		Mars.		Jupiter.		Saturn.		Neptune.	
	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Jan. 1	18 42·5	S. 23·1	14 55·6	S. 22·1	19 25·2	S. 24·2	20 39·5	S. 20·2	10 12·8	N. 14·8	23 33·6	S. 4·2	6 57·6	N. 22·3	8 16·2	N. 19·5
„ 6	19 4·5	22·6	20 22·1	S. 19·9	20 0·0	22·7	21 4·9	18·5	10 12·3	15·1	23 36·3	3·9	6 55·8	22·4	8 15·6	19·5
„ 11	19 26·3	22·0	0 38·0	N. 9·3	20 33·2	20·6	21 29·6	16·6	10 10·5	15·5	23 3·3	3·6	6 54·0	22·4	8 15·1	19·5
„ 16	19 48·0	21·1	4 44·7	N. 26·7	21 2·7	18·0	21 53·7	14·5	10 7·4	15·9	23 42·4	3·2	6 52·3	22·4	8 14·5	19·5
„ 21	20 9·3	20·1	9 0·7	N. 16·5	21 24·9	15·3	22 17·4	12·3	10 2·9	16·5	23 45·7	2·8	6 50·6	22·5	8 13·9	19·6
„ 26	20 30·3	19·0	12 51·8	S. 10·9	21 34·6	13·1	22 40·5	9·9	9 57·3	17·1	23 49·2	2·5	6 49·0	22·5	8 13·3	19·6
„ 31	20 51·0	S. 17·7	17 44·3	S. 26·9	21 27·0	S. 12·2	23 3·1	S. 7·5	9 50·6	N. 17·8	23 52·8	S. 2·0	6 47·5	N. 22·6	8 12·8	N. 19·6

TABLE 63.

Date.	Greenwich Noon.														Midnight.	
	Sun.			Mars.					Jupiter.						Moon.	
	P	B	L		P	B	L	T	P	B	L_1	L_2	T_1	T_2	P	
	°	°	°		°	°	°	h. m.	°	°	°	°	h. m.	h. m.	°	
Jan. 1 ...	+ 2·4	−3·1	313·5	Jan. 1 ...	+ 9·5	+19·4	331·5	1 57 *e*	Jan. 1 ...	−25·4	+1·8	215·9	288·4	3 57 *e*	1 59 *e*	Jan. 1	+14·8
„ 6 ...	− 0·1	3·6	247·6	„ 7 ...	9·4	19·1	277·2	5 40 *e*	„ 8 ...	25·4	1·8	239·6	258·7	3 18 *e*	2 49 *e*	„ 6	−14·2
„ 11 ...	2·5	4·2	181·8	„ 13 ...	9·0	18·7	223·3	9 20 *e*	„ 15 ...	25·4	1·9	263·2	228·9	2 40 *e*	3 33 *e*	„ 11	−22·1
„ 16 ...	4·9	4·7	116·0	„ 19 ...	8·3	18·2	170·0	0 23 *m*	„ 22 ...	25·5	1·9	286·8	199·1	2 1 *e*	4 27 *e*	„ 16	− 5·8
„ 21 ...	7·2	5·2	50·1	„ 25 ...	7·3	17·7	117·1	4 0 *m*	„ 29 ...	−25·5	+1·9	310·3	169·2	1 22 *e*	5 16 *e*	„ 21	+16·5
„ 26 ...	9·4	5·6	344·3	„ 31 ...	+ 6·1	+17·1	64·5	7 36 *m*								„ 25	+21·7
„ 31 ...	−11·6	−6·0	278·5													„ 31	− 0·5

P is the position angle of the North end of the body's axis measured eastward from the North point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. T is the time of transit of the zero meridian across the centre of the disc. In the case of Jupiter System I refers to the rapidly rotating equatorial zone; System II to the temperate zones, which rotate more slowly. To find intermediate passages of the zero meridian of either system across the centre of the disc, apply to T_1 T_2 multiples of $9^h\ 50^m{\cdot}7$, $9^h\ 55^m{\cdot}8$ respectively. In the case of Mars apply multiples of $24^h\ 37^m$.

The data for the Moon in the Second Table are given for Greenwich Midnight, *i.e.*, the Midnight at the end of the given day. Those for the planets were given for midnight last year, but are now given for Noon.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN has begun to move Northward. It is nearest the Earth on 2nd at 1^h *e*. Its semi-diameter diminishes from 16′ 17″ to 16′ 15″. Sunrise changes from $8^h\ 8^m$ to $7^h\ 43^m$; sunset from $3^h\ 59^m$ to $4^h\ 45^m$. There is now considerable solar activity, and a constant watch should be kept on the disc.

MERCURY is an evening star, at greatest elongation, 18½° E. of Sun, on 20th. Semi-diameter increases from 2½″ to 4½″. Illumination nearly Full on 1st, $\frac{1}{12}$ on 31st.

VENUS is an evening star, well placed for observation at the end of the month. Semi-diameter 6″. Illumination nearly Full.

TABLE 64. Occultations of Stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance.		Reäppearance.	
			Time.	Angle from N. to E.	Time.	Angle from N. to E.
1916.			h. m.	°	h. m.	°
Jan. 2 ...	*b* Scorpii	4·7	6 25 *m*	50	7 1 *m*	345
„ 13 ...	26 Arietis	6·2	5 46 *e*	68	7 8 *e*	238
„ 16 ...	χ Tauri	5·3	0 5 *m*	132	0 58 *m*	225
„ 16 ...	WZC 341	6·6	5 55 *e*	107	—	—
„ 16 ...	WZC 350	6·8	10 9 *e*	148	—	—
„ 18 ...	WZC 421	7·4	1 0 *m*	121	—	—
„ 18 ...	BD+24°·1470	7·0	8 49 *e*	129	—	—
„ 19 ...	ω Geminorum	5·2	0 47 *m*	172	1 21 *m*	225
„ 19 ...	192 B Geminorum	6·3	5 59 *e*	73	6 58 *e*	302
„ 22 ...	WZC 646	6·7	—	—	4 2 *m*	357
„ 23 ...	43 Leonis	6·3	5 16 *m*	172	6 1 *m*	255
„ 25 ...	WZC 771	7·1	—	—	6 44 *m*	270
„ 25 ...	*q* Virginis	5·3	11 39 *e*	165	0 24 *m**	258

The asterisk indicates the day following that given in the date column.

From New to Full disappearances occur at the Dark Limb, from Full to New reäppearances.

MARS is a morning star in Leo, stationary on 2nd, near Regulus on the 20th, rising about 7h *e*. Semi-diameter 7″, width of defective lune ½″. The planet is approaching opposition, and is nearest the Earth on February 9th. The North Pole of the planet is now turned towards the Earth and Sun. The Vernal Equinox of the planet's northern hemisphere took place on October 19th, and the planet is in the part of its orbit that corresponds with early May on Earth. The coming opposition is unfavourable as regards distance, but favourable as regards altitude.

JUPITER is an evening star in Pisces; has commenced to advance in R.A. Equatorial diameter 37″, Polar 35″. Defect of illumination on East Limb, 0″·3.

Configuration of satellites at 7h *e* for an inverting telescope.

JUPITER'S SATELLITES.

Day.	West.	East.	Day.	West.	East.
Jan. 1	41 ○	3 2●	Jan. 17	431 ◎	
,, 2	4 ○	312	,, 18	432 ○	1
,, 3	324 ○	1●	,, 19	¾ ○	2 1●
,, 4	321 ○	4	,, 20	14 ○	2 3●
,, 5	3 ○	124	,, 21	2 ○	143
,, 6	1 ○	¾ 4	,, 22	12 ○	34
,, 7	2 ○	134	,, 23	○	1324
,, 8	1 ○	34 2●	,, 24	¾ ○	24
,, 9	○	3124	,, 25	32 ○	14
,, 10	321 ○	4	,, 26	3 ○	24 1●
,, 11	32 ⊙	4	,, 27	31 ○	24
,, 12	34 ○	12	,, 28	2 ○	143
,, 13	41 ○	32	,, 29	¼ 4 ○	3
,, 14	42 ○	13	,, 30	4 ○	123
,, 15	412 ○	3	,, 31	413 ○	2
,, 16	4 ○	132			

The following satellite phenomena are visible at Greenwich all in the evening hours:—1d 8h 53m 52s II. Ec. R.; 2d 7h 38m III. Tr. I., 8h 36m I. Tr. I., 9h 53m I. Sh. I.; 3d 5h 56m I. Oc. D., 9h 26m 2s I. Ec. R.; 4d 4h 22m I. Sh. I., 5h 20m I. Tr. E., 6h 34m I. Sh. E.; 6d 5h 45m 14s III. Ec. R.; 8d 6h 15m II. Oc. D.; 10d 6h 30m II. Sh. E., 7h 55m I. Oc. D.; 11d 5h 5m I. Tr. I., 6h 18m I. Sh. I., 7h 19m I. Tr. E., 8h 30m I. Sh. E.; 12d 5h 50m 14s I. Ec. R.; 13d 5h 9m III. Oc. R., 7h 5m 43s III. Ec. D., 9h 46m 22s III. Ec. R.; 15d 9h 1m II. Oc. D.; 17d 6h 25m II. Sh. I., 6h 53m II. Tr. E., 9h 7m II. Sh. E.; 18d 7h 5m I. Tr. I., 8h 13m I. Sh. I., 9h 19m I. Tr. E.; 19d 7h 45m 33s I. Ec. R.; 20d 4h 55m I. Sh. E., 6h 26m III. Oc. D., 9h 6m IV. Oc. D., 9h 28m III. Oc. R.; 24d 6h 53m II. Tr. I., 9h 1m II. Sh. I.; 25d 9h 5m I. Tr. I.; 26d 6h 9m 4s II. Ec. R., 6h 24m I. Oc. D.; 27d 5h 50m I. Tr. E., 6h 51m I. Sh. E.; 31d 5h 12m III. Sh. I., 7h 48m III. Sh. E.

Satellite IV. will undergo eclipse for the last time on the 21st at 9h *m*. It will then escape eclipse for two years.

The Eclipse reäppearances of Satellites I., II., and both phases of those of III. IV., occur low right of the disc in an inverting telescope, taking the direction of the belts as horizontal.

SATURN is in opposition on the 4th in Gemini. Rises at sunset. Angle P−6°·9, B−25°·0. Polar semi-diameter 9½″, Major axis of ring 46½″, minor 19¾″. Eastern elongations of Tethys (every fourth given) 1d 8h·5 *m*, 8d 9h·7 *e*, 16d 10h·8 *m*, 23d midnight, 31d 1h·1 *e*; of Dione (every third given) 3d 3h·3 *e*, 11d 8h·1 *e*, 20d 1h·0 *m*, 28d 5h·8 *m*; of Rhea (every second given) 4d 9h·1 *m*, 13d 9h·7 *m*, 22d 10h·3 *m*, 31d 10h·9 *m*. For Titan and Japetus E., W. stand for Eastern and Western elongations; S., I. for Superior and Inferior Conjunctions. Titan 6d 6h·9 *m* E., 13d 10h·6 *e* W., 22d 4h·2 *m* E., 29d 8h·0 *e* W. Japetus 15d 10h·0 *e* W.

URANUS is practically invisible. It is 1° N. of Venus on 6th, 15′ N. of Mercury on 17th.

NEPTUNE is in opposition on the 22nd in Cancer. Semi-diameter 1″.

THE MOON.—New 5d 4h 4m *m*. First quarter 12d 3h 38m *m*. Full 20d 8h 29m *m*. Last quarter 28d 0h 35m *m*. Perigee 4d 2h *e*. Apogee 17d 5h *m*, semi-diameter 16′ 45″, 14′ 44″ respectively. Maximum librations 1d 6° N., 10d 7° W., 13d 7° S., 26d 7° E., 28d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon. (See Table 64.)

PARTIAL ECLIPSE OF THE MOON, JANUARY 20TH.—The Moon will enter the penumbra at 6h 5m *m*, and leave it at 11h 14m *m*; it will enter the shadow at 7h 55m *m*, and leave it at 9h 24m *m*. Greatest eclipse (⅓ of Moon's diameter) 8h 39m *m*. The Moon sets in London about the time of entry into the shadow. The eclipse will be visible in America under favourable circumstances.

TOTAL ECLIPSE OF THE SUN, FEBRUARY 3RD.—Details of the track of totality are given in Notes on Astronomy on another page. Particulars of the partial eclipse in the British Isles will be given next month.

TABLE 65.

Day.	α Arietis.	Aldebaran.	Sirius.
	N. Dec. 23° 4′.	N. Dec. 16° 21′.	S. Dec. 16° 36′.
	h. m. s.	h. m. s.	h. m. s.
Dec. 31	7 25 54·48 *e*	9 54 10·77 *e*	0 4 10·19 *m**
Jan. 10	6 46 35·24 *e*	9 14 51·63 *e*	11 24 51·13 *e*
,, 20	6 7 15·99 *e*	8 35 32·46 *e*	10 45 32·04 *e*
,, 30	5 27 56·75 *e*	7 56 13·26 *e*	10 6 12·90 *e*

* Morning of Jan. 1st.

GREENWICH TIMES OF MERIDIAN TRANSIT OF CERTAIN BRIGHT STARS.—These are given to facilitate the determination of time by observations with small transit instruments. The times for intermediate days may be obtained by simple interpolation. The Greenwich time of the stars crossing the meridians of other places may be obtained by expressing the longitude of these places in time, diminishing them by 9s·83 per hour, and proportionately for fractions of an hour, then applying the result to the tabular time—positively for West longitudes, negatively for East ones.

SUN after clock Jan. 1, 191^{s}·01, Jan. 6, 330^{s}·65, Jan. 11, 459^{s}·15, Jan. 16, 572^{s}·98, Jan. 21, 669^{s}·70; Jan. 26, 747^{s}·80, Jan. 31, 806^{s}·39. These are the equations of time for the moment of solar transit at Greenwich.

VARIABLE STARS.—Stars reaching their maxima in or near January, 1916, are included. The lists in recent months may also be consulted. (See Table 66.)

EPHEMERIS OF MELLISH'S COMET (a. 1915).—For 11^{h} *e*:

	R.A. H. M. S.	N.Dec. ° ′		R.A. H. M. S.	N.Dec. ° ′
Dec. 17	3 42 34	6 10	Jan. 2	3 27 22	10 28
„ 21	3 37 45	7 20	„ 6	3 25 9	11 24
„ 25	3 33 38	8 26	„ 10	3 23 30	12 16
„ 29	3 30 11	9 29	„ 14	3 22 23	13 5

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A. °	Radiant. Dec. °	Remarks.
Jan. 2–3 ...	230	+ 53	Swift; long paths.
„ 3 ...	156	+ 41	Swift.
„ 5–11 ...	332	+ 35	Slow.
„ 17–25 ...	143	+ 38	Swift.
„ 17–23 ...	159	+ 27	Swift.
„ 25 ...	131	+ 32	Swift.
„ 29 ...	213	+ 52	Swift.

The shower on January 2–3 is conspicuous.

TABLE 66. LONG-PERIOD VARIABLE STARS.

Star.	Right Ascension. h. m. s.	Declination. ° ′	Magnitudes.	Period. d.	Date of Maximum.
S Ceti	0 19 44	− 9 48	7·3 to 13·6	321	1916—Jan. 17
U Persei	1 53 57	+54 24	7·0 to 10·9	317	„ Jan. 6
o Ceti (Mira)	2 15 3	− 3 21	2·0 to 9·6	331	„ Jan. 8
R Ceti	2 21 42	0 34	7·5 to 12·8	167	„ Feb. 4
S Hydrae	8 49 8	+ 3 23	7·5 to 12·5	256	„ Jan. 20
R Leon. Min.	9 40 29	+34 54	7·1 to 12·9	371	„ Jan. 20
χ Cygni	19 47 19	+32 42	4·2 to 13·2	405	„ Feb. 2

Special attention is called to the Maximum of Mira Ceti. χ Cygni should also be watched.

Minima of Algol 2^{d} 2^{h}·4 *e*, 11^{d} 5^{h}·0 *m*, 14^{d} 1^{h}·8 *m*, 16^{d} 10^{h}·6 *e*, 19^{d} 7^{h}·4 *e*, 22^{d} 4^{h}·2 *e*, 25^{d} 1^{h}·0 *e*. Period 2^{d} 20^{h} 48^{m}·9.

Principal Minima of β Lyrae 5^{d} 8^{h}·8 *e*, 18^{d} 6^{h}·6 *e*, 31^{d} 4^{h}·4 *e*. Period 12^{d} 21^{h} 47^{m}·5.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE TOTAL SOLAR ECLIPSE OF 1916 (FEBRUARY 3RD).—Totality in this eclipse is visible from parts of Colombia and Venezuela, and the whole of the island of Guadeloupe. Totality lasts two and a half minutes, and the Sun's altitude will be great. The width of the track of totality is about sixty-eight miles. The following table gives a few points, from which the limits of the totality zone may be laid down:—

Long. West of Greenwich. °	Lat. of N. Limit. ° ′	Lat. of S. Limit. ° ′
80 ...	N. 4 53 ...	N. 3 51
75 ...	7 1 ...	5 55
70 ...	10 3 ...	8 52
65 ...	13 54 ...	12 40

The central line runs near Baudo, Medellin, San José de Cucuta, Barquisimeto, San Felipe, Golfo Triste, the last being some eighty miles west of Caracas. Owing to the war no official expeditions are going from Europe, but it is to be hoped that the eclipse will not pass wholly unobserved. The type of corona associated with waxing solar activity is imperfectly known. The conditions of visibility of the Partial Phase in the British Isles will be given next month.

THE PLANET JUPITER has been a very brilliant object in our night skies, being near perihelion, at a convenient altitude for British observers. The Rev. T. E. R. Phillips, President of the British Astronomical Association, chose it as the theme of his address at the annual general meeting, dwelling in particular on the periodic changes in the rotation-time of the Red Spot, and the disturbances produced by the Dark South Tropical marking when it overtakes the Red Spot, and apparently accelerates its motion. This was first pointed out by M. E. M. Antoniadi, and has been confirmed at each conjunction of the markings. There was a conjunction in 1902, and they have happened at intervals of about two years, the rotation-period of the dark marking being some twenty seconds less than that of the Red Spot. Mr. Denning gives an interesting discussion of the subject, with diagrams, in *The Journal of the Royal Astronomical Society of Canada*, September, 1915. The Red Spot was not detected till 1872, but Mr. Denning shows that the hollow in the adjacent belt, which is an inseparable companion of the spot, can be traced back to 1831, when it was frequently drawn by Schwabe. Mr. Denning gives its rotation-time for each year from 1831 to 1915. I give a summary of these, taking ten-yearly means for the period 1831 to 1900, but giving the annual means for the later.

Year.	Mean Rotation-time of Red Spot. h. m. s.	Year.	Mean Rotation-time of Red Spot. h. m. s.
1831 to 1840	9 55 34·3	1905	9 55 41·2
1841 „ 1850 ...	35·3	1906 ...	39·5
1851 „ 1860 ...	36·7	1907 ...	40·9
1861 „ 1870 ...	34·8	1908 ...	39·6
1871 „ 1880 ...	34·1	1909 ...	40·3
1881 „ 1890 ...	39·1	1910 ...	37·4
1891 „ 1900 ...	41·2	1911 ...	37·4
1901 ...	40·7	1912 ...	37·2
1902 ...	39·6	1913 ...	35·7
1903 ...	40·2	1914 ...	33·6
1904 ...	39·7	1915 ...	36·6

The chief characteristics of the table are the slow rise to a maximum in 1859, the rapid fall to a minimum in 1877, the rise to a high maximum in 1898, then the curious oscillations in a period of two years, accompanied by a rapid fall till 1914; since then there has been a recovery.

XUM

There is some evidence of a period of about forty years, but it is not very regular. The Red Spot is clearly quite unsuitable to use as a zero of longitude, and satisfaction will be felt that the American Ephemeris has abandoned the attempt to use it.

Mr. Denning thinks it not unlikely that the great spot observed by Hooke and Cassini from 1664 to 1672 was really identical with the Red Spot. In this case there would seem to be a special region of permanent disturbance on the planet. This supposition makes the capricious wanderings of the spot harder to understand. The extent of these wanderings between 1910 and 1914 was one hundred and twenty thousand miles, or 153° of longitude: this is equivalent to an oscillation between West Australia and Brazil (by the African route). The shift is not always in one direction, but backwards and forwards in a manner that cannot be entirely reduced to rule.

BETELGEUX.—Mr. T. W. Backhouse notes in *The Observatory* for November that this bright red star, which is irregularly variable, is now unusually faint, its brightness being midway between Aldebaran and Bellatrix. This is a very easy object for study with the naked eye.

FAINT STAR WITH LARGE PROPER MOTION.—Professor Wolf gives an interesting case of a twelfth-magnitude star which has an annual proper motion of 1″·87 in direction 276°. Its approximate place for the equinox of 1875 is R.A. 12h. 27m. 9s., N. Decl. 9° 42′·2. This is in all probability an expiring sun, near the end of its career.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C.

TOXICITY OF WOOD PRESERVATIVES.—In order to determine the relative efficiency of various wood preservatives, Messrs. R. M. Fleming and C. J. Humphrey (*Journ. Ind. Eng. Chem.*, 1915, VII, 652) have made a series of comparative tests upon the fungus *Fomes annosus*, which was cultivated for the purpose in a nutrient agar medium. Cultures of two to three weeks' growth were found to offer greater resistance to the action of the preservatives than older cultures. Taking an average coal-tar creosote as the standard, the tests showed that beechwood creosote was more than twice as toxic to the fungus. A proprietary article, composed of a mixture of pyroligneous acid and wood tar, was only half as effective as coal-tar creosote; while hardwood tar and tar from the wood of Douglas fir were also inferior to the standard. Another special preparation from soft wood was still less toxic. The most poisonous constituents of coal-tar creosote were contained in the fractions boiling between 215° and 305° C., although possibly the phenolic compounds in the fractions of lower boiling-point might be equally effective. The distillates from water-gas tar had less effect than coal-tar creosote; while petroleum oils had little, if any, toxic action. Zinc sulphate was as effective as zinc chloride, and a mixture of zinc chloride and aluminium sulphate gave as good results as zinc chloride by itself. On the other hand, an emulsion of zinc chloride, creosote, and a small amount of copper was greatly inferior to zinc chloride in its toxic effect upon the fungus.

AN ALLOTROPIC MODIFICATION OF LEAD.—A new form of lead is described by Dr. H. Heller in the *Zeit. Physik. Chem.*, and an abstract of the paper is given in *The Journal Chemical Society* (1915, CVIII, 634). It is obtained by leaving pure lead for several days in an acidified solution of lead acetate until it becomes brittle and can be powdered readily. This new modification of the element, which is termed "grey lead," may also be obtained by treating the lead with lead nitrate solution or lead chloride solution, though much more slowly in the case of the latter. Proof that the change is due to the presence of lead ions is afforded by the fact that no such transformation in the metal takes place when lead is immersed in acetic acid, nitric acid, or a solution of sodium acetate.

GEOGRAPHY.

By ALEXANDER SCOTT, M.A., B.Sc.

PSEUDO-GLACIAL FEATURES IN DALMATIA.—The coast line of Dalmatia possesses many characteristics which are typical of glaciated regions, although positive evidence of glacial action is wanting. The coast lands and islands have rounded contours, crags and pinnacles being absent, and in many places a kind of "crag and tail" structure is found. The valleys are generally U-shaped, and are either spurless or have the spurs faceted, as in the fiord of Cattaro; while hanging valleys are also common, the floors often lying several hundred feet above that of the main valley. In *The Geographical Journal* (August, 1915) Professor Gregory discusses the origin of these features, and concludes that they are not glacial. While glaciers undoubtedly existed at one time in this region, these were very small, and were confined to the higher parts of the mountains. The coast lands indicate that these glaciers never reached sea-level, since erratics, striae, and so forth are absent. Hence the features are pseudo-glacial, and may be explained in various ways. The smooth contours arise from the weathering of limestone, the jointed nature of which is responsible for the "crag and tail" structures and the cutting back of the spurs. The spurless walls and the hanging valleys are due mainly to faulting, though some of the latter may arise from river erosion in a series of porous rocks, which inhibit the tendency of the tributaries to cut down to the base level of the main valleys.

BRITISH EARTHQUAKES.—In the same *Journal* (November, 1915) Dr. Davison discusses at some length the more important earthquakes which have occurred in Great Britain since 1889. These earthquake shocks, which number three hundred and fifty-seven in all, may be divided into two classes: those which occur sporadically throughout the country, the same district seldom receiving more than two shocks during the period; and those which, like the Comrie earthquakes, occur in series in particular districts. The former includes most of the larger shocks, such as those of Inverness (1890 and 1901), Hereford (1896), Derby (1903 and 1904), Doncaster (1905), and so forth: the latter includes the series of forty-one shocks in Glen Garry (1889–99), and of one hundred and eighty-six shocks in the Ochil Hills (1900–14). A consideration of these earthquakes shows their close connection with geological faults; thus the Inverness shocks arose in a fault lying along the line of the Caledonian Canal, and the Ochil Hills series in the well-known fault along the southern margin of the range. In the English examples the faults are often hypothetical, but in Scotland most of the shocks can be assigned to well-known faults, which in most cases belong to the Caledonian system of faulting (north-west and south-east trend). The only exceptions are the Loch Broom earthquake of 1892, and the Glasgow ones of 1910. In Wales there is less uniformity, the contributing faults belonging to the Caledonian, Armorican, and Malvernian systems. Several earthquakes, such as the Hereford one, belong to the group of twin earthquakes, and are due to simultaneous slips in two detached foci. These must arise by rotation of the strata about a point between the two foci, the displacement being zero at this point. Twin earthquakes also differ from simple earthquakes in originating in transverse faults, the latter arising usually in strike faults. It is also significant that the simple type can generally be connected with known faults; while in the case of the twin type the fault is more deep-seated, and therefore generally hypothetical.

GEOLOGY.

By G. W. TYRRELL, F.G.S., A.R.C.S.

WIND DEPOSITS OF PRE-CAMBRIAN AGE.—Much of the North American Cordilleras on both sides of the boundary between the United States and Canada is built of an enormous series of Pre-Cambrian sedimentary rocks,

still largely unaltered, and lying conformably below the *Olenellus* zone of the Cambrian. This great group of rocks is locally known as the Beltian system. It is mainly composed of thick formations of limestone, quartzite, and metargillite (altered mudstone and shale), which, in the Selkirk Mountains of Canada, attain the enormous aggregate thickness of thirty-two thousand seven hundred and fifty feet, or over six miles. These rocks are described by Professor R. A. Daly in *Memoir* No. 68 of the Geological Survey of Canada, in which he records his geological observations along the Canadian Pacific Railway between Golden and Kamloops, British Columbia. While most of the Beltian sediments were laid down under water, there is clear evidence that the wind was also a powerful factor in their accumulation. Some of the quartzites are composed almost entirely of quartz in perfectly rounded grains, some of which have a mean volume only one-fiftieth of the smallest grains that can be rounded by running water. These grains, therefore, could only have been transported by wind. Further evidence of aeolian origin is given by the purity of the quartzites. One of the limestone formations contains abundant rounded grains of quartz and felspar which are far too small to have been rounded by water action. These were probably blown out to the sea in which the limestone was forming.

Moreover, many of the quartzites are much too fine-grained to be considered as indurated sandstones. They are very homogeneous, massively bedded, and have the characters of a hardened siliceous mud. They represent colossal accumulations of quartz and subordinate felspar, with varying amounts of muddy and calcareous impurities. They are unlike any water-transported deposit of similar fineness of grain and areal magnitude known to be forming upon the present sea floor. Professor Daly believes that they represent ancient formations of loess, similar to the wind-transported dust (loess) which covers a large part of China, having been carried by the wind from the interior deserts of Asia. He finds confirmation of this mode of origin in the chemical and mineralogical composition of these quartzites, in their extraordinary homogeneity and thick bedding, and in their intimate association with the contemporaneous dune-sand quartzites.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

THE WEATHER OF DECEMBER.—There is a considerable variation in the mean temperature of December in different years; thus in 1890 it was 29°·9, and in 1852 47°·6. Generally the month may be said to be mild and rather stormy, for the real severity of winter seldom commences before the last week; while the month and year expire either in gloomy, damp weather, or in a state of frost and snow, according to the prevailing character of the season during the few previous weeks. If the month should prove mild, a considerable quantity of rain frequently falls; but if cold, it is almost invariably dry. Gales from the south-west are now and then very heavy, accompanied by a great depression of the barometer. It was a very mild month in the years 1842, 1852, 1857, 1898, 1900, 1910, 1911, and 1912. On the other hand, it was a very cold month in the years 1844, 1846, 1874, 1879, and 1890.

The average temperature for December at the Royal Observatory, Greenwich, is 39°·9; the mean maximum is 44°·2, and the mean minimum 35°·0. The absolute maximum temperature was 62°·4 on the 10th in 1848, and the absolute minimum 8°·0 on Christmas Day in 1860. The average number of days on which the temperature falls to or below the freezing-point is ten. The maximum temperature for the day did not reach 25° on the 21st and 22nd in 1855; on the 31st in 1874; and on the 22nd in 1890.

The average rainfall is 1·95-in.; the greatest amount was 5·97-in. in 1914, and the least 0·31-in. in 1873. The heaviest fall on one day was 1·10-in. on the 23rd in 1833. The average number of "rain days" (*i.e.*, days on which 0·01-in. fell) is 14·2; the greatest number of days was twenty-three in 1868, and the least six in 1873. There are on the average about three days with snow and four days with fog. The average amount of bright sunshine at the Kew Observatory, Richmond, is thirty-six hours, or fifteen per cent. of the possible duration.

The mean barometric pressure for December in London is 29·955-in.; the highest mean was 30·423-in. in 1843, and the lowest mean 29·490-in. in 1876.

THE MECHANISM OF CYCLONES.—At the recent meeting of the British Association, Mr. F. J. W. Whipple read a paper on "The Mechanism of Cyclones." He pointed out that the pressure and temperature distributions in the cyclones of the temperate zone could be deduced from the meteorographs carried by pilot balloons. Up to the level of eight kilometres or nine kilometres the cyclone seemed to be composed of air cooler than the surrounding air; at greater heights, in the atmosphere, the cyclone contained comparatively warm air; the lower limit of the stratosphere was depressed in the cyclone. The air in the lower part of a cyclone seemed to have recently ascended, and that in the upper part to have recently descended, and thus the arrival of a cyclone was marked by an outflow of air at the bottom of the stratosphere and by an inflow below. Assuming that there was no direct exchange of heat, the outflow seemed to be concentrated between the seventh and the ninth kilometre, and amounted to 6·5 times the loss of air estimated by the fall of pressure on the surface of the earth. A cyclone might be regarded as a disturbance in the stream of air which flowed west to east in the temperate zone. Making allowance for the curvature in progressive motion of the isobars, the gradient wind at certain heights was much less than it would have been if the curvature were inappreciable, and at these heights the cyclone appeared to move under the influence of suction applied at the base of the stratosphere. In the explanation of the phenomena it had to be considered that the flow of air was not entirely horizontal at any level.

RAINFALL IN THE CROYDON DISTRICT.—Some of the local Natural History and Scientific Societies in various parts of the country render great service to meteorology by the collection of rainfall and other statistics in their special areas. One of the best reports is that issued by the Croydon Natural History Society, the work being carried out by a small committee, of which Mr. F. Campbell Bayard is the secretary. A printed sheet has been issued monthly since January, 1888, giving the rainfall for each day at a large number of stations in the district covered by the operations of the Society. The number of returns included in the report for 1914 is one hundred and four. The cost of the printing of the monthly reports is defrayed by voluntary contributions. Anyone who would like to see these reports should ask Mr. F. Campbell Bayard, Alcester Road, Wallington, to send him a copy. With regard to the rainfall of 1914, it is shown that the four months, February, March, November, and December, were very wet, December being exceptionally so, whilst the remaining eight months were dry, January, June, and October being especially so. The greatest rainfall in the district during the year was 37·82-in. at the reservoir, Caterham, seven hundred and five feet above sea level; and the least rainfall 18·14-in. at Telegraph Hill, Nunhead, one hundred and thirty-five feet above sea level. At the latter station, however, the rain-gauge is eight feet six inches above the ground.

MICROSCOPY.

By F.R.M.S.

NOTES ON *SOLPUGA*.—The genus *Solpuga*, being entirely African, is represented here only in our museums and private collections, although other members of the family are met with in Asia and America. There are about fifty species, and they are now usually classed as coming

between the scorpions and the spiders; but, though bearing some superficial resemblance to the latter, they differ from them in possessing no spinning organs, and having the abdomen divided into segments. Specimens received from Orange Free State, measuring as they do about one and a half inches, cannot be called microscopic; but some details connected with them are of considerable interest to the microscopist. At first sight they appear to have ten legs, of which the first and last pairs are considerably longer and stronger than those which are intermediate. The first pair, however, are the pedipalpi, consisting of six joints; the terminal one ending in the receptacle for a curious sense organ, which can be protruded at will, and by some writers is regarded as suctorial, but by others as an organ of smell. The pedipalpi are freely covered with hairs of four different kinds, the most numerous having parallel-sided shafts, hollow until near the extremity, where they become solid, and are divided into two diverging points. At intervals there are also some long silky hairs, tapering to a point, and extending on either side of the creature, so as to cover a circle at least three inches in diameter; whilst numerous shorter tapering hairs are found spread over the pedipalpi. In addition to these, there are a few hairs of a distinctive character confined to the terminal joint: they are hollow, and very finely cross-striated, with shafts which broaden out at the ends, where they are knobbed and rounded, each of them containing a thread-like nerve. The second pair are true legs, but are never used in walking, being carried high above the ground, apparently as feelers; they do not terminate with the usual claws, but in a dense brush of short hairs: those they bear generally are similar to the hairs on the pedipalpi, except that the knobbed form are more numerous in proportion, and appear also on the last joint but one. The third and fourth pairs are used as walking legs, and resemble each other: they are covered with hairs similar in shape to those already described, but the knobbed form are absent. The tarsus is five-jointed, and armed with strong spines on the underside; the last joint bears two long claws, which differ from those of insects by being themselves jointed near their ends. The fifth and last pair, which are really the fourth pair of legs, differ from those preceding, inasmuch as the femora are divided into five joints, from the first three of which hang the five malleoli—sometimes referred to as the "racket organs." The tarsus is seven-jointed, with spines and claws, and with hairs of the same kind as those on the second and third legs; but those with bifid ends are most numerous. The malleoli are obliquely fan-shaped bodies suspended crosswise from the underside of the leg by short stems, which allow them to swing freely, and through which trachea and nerves pass into and spread out over the interior of the fans. They vary considerably in size according to the individual to which they belong, the largest in my possession being as much as 0·14 inch, whilst the smallest is only 0·035 inch in greatest width; those on the same leg are graduated in size, the smallest being nearest to the body. They appear to be formed of two delicate translucent membranes united at their edges, and having a double border along the convex margin of the fan; the nerve fibres seem to end at the inner of these, but with an intervening blank space, the outer border is crossed by vertical lines not more than the seventeen thousandth of an inch apart, and there is some suspicion that minute orifices exist along this edge. Their internal structure was described by H. Rulemann in 1908, who gave two plates in illustration of his paper. The chelicerae are enormously developed, and of these there are two pairs, extending in front and opening vertically, fringed, especially on the inner side near the base, with a row of bipennate branching hairs: they are of great strength, with sharp, curved points, and being toothed upon the opposing edges would be terrible weapons when vigorously used. On each of the upper chelicerae of the male there is a curious organ, known as the "flagellum," which in the species described is curved backwards, and has a spear-pointed end. The natives of those parts of the world where the *Solpuga* is found have an idea that it is poisonous: this, however, seems to be erroneous, as a careful dissection and examination has failed to find any poison-sac or orifice through which fluid could pass, though undoubtedly the double bite would itself be severe. The great bases of the chelicerae contain muscles only, which are brilliant objects in the polariscope.

R. T. L.

A "BORDERED PIT."—One of the interesting mechanical devices found in plant life is known as a "bordered pit." A "bordered pit" can be well studied in the wood of a conifer, such as *Pinus sylvestris* or *Pinus excelsa*. This structure was brought prominently before microscopists by Dr. Carpenter, who used it as a test for achromatism. There is a figure of it in *The Achromatic Microscope* by Richard Beck, Plate XI (1865), which

FIGURE 301.

shows how it appeared to that generation of microscopists. Many years ago a photomicrograph I had taken showed that there was a good deal more in this structure than was suspected. Briefly it is, as I said at that time, an ordinary mechanical contrivance known as a "clack valve," such as may be found in the scullery pump in many houses in the country. This is recognised to be the case, and the valve itself is now called the "torus."

Figure 301 (1) shows this structure as interpreted by Carpenter and Beck.

Figure 301 (2), from my photomicrograph, shows the "torus." In the figure of this structure in the ninth edition of the "Encyclopaedia Britannica" the membrane is shown without the thickening in the middle.

Figures 301 (1) and (2), which are found in botanical books of the present day, are still incomplete, for examination under critical light shows that the "torus" is held by a number of radial threads, as in Figure 301 (3), thereby proving that the structure is a clack valve, and not merely a thickening of a membrane, as is supposed.

Of course, there is now no need to advance the theory that water is transmitted through these "bordered pits" by osmosis.

It may interest microscopists to know that this structure was seen by an English microscope (Powell No. 1) forty years old, with a one-sixth objective, dated 1854, and a one-twelfth (Lister's formula with a triple front) of 1850, in conjunction with a C, or one-inch, Huyghenian eyepiece. Those glasses after sixty years are now as bright and as clear as the day they were finished.

EDWARD M. NELSON.

PHOTOGRAPHY.

By EDGAR SENIOR.

PHOTO-MICROGRAPHS OF MINUTE OBJECTS, AND HOW THEY MAY BE IMPROVED.—A great deal has been written at various times concerning the power of resolution possessed by microscope objectives—a subject which is always of great interest to those who practise photo-micrography with high powers. Those who are qualified to pass any opinion on the matter generally agree that the limit of resolving power is equal to about

half the wave-length of the light employed. It would therefore appear from this that any further improvement must rest in the possibility of being able to employ light of shorter wave-length than that in general use. An explanation of this is not difficult to find if we remember that, optically speaking, there are only two things which affect resolving power, one being the numerical aperture (N.A.) of the lens and the other the wave-length of the light employed. Now, although objectives have been made having an aperture, or N.A., of 1·60, those which are in general use do not exceed N.A. 1·40. This being the case, any advance must be looked for in the direction of the light. The wave-length of the light which has the greatest effect visually is generally stated to be about five thousand three hundred and forty-seven tenth-metres, or forty-seven thousand five hundred waves to the inch; and, according to Abbe, the resolving power of any objective is found by simply multiplying twice the number of light-waves to the inch by the N.A. of the objective, so that visually we should be able with a lens of N.A. 1·40 to see the image of objects, whether in lines or dots, which were separated by an interval of one hundred and thirty-three thousandth of an inch. When photographing, however, with the same objective, we should be able to use light of much shorter wave-length, since the light which is the most actinic is situate at the blue-violet end of the spectrum in the region where the waves are about sixty thousand to the inch; and by the same law the photographic plate should be able to furnish a record of images from objects as close together as the one hundred and sixty-eight thousandth of an inch. This is not new, and has been recognised for a considerable time; and, as any further increase in the size of the aperture (N.A.) of the objective appears unlikely, so far as we are able to see at present, any increase in resolution will depend—as already pointed out—in employing light of shorter wave-length. To this end ultra-violet light has been made use of, lenses being constructed of quartz and fluorite, which transmit these rays freely, the focusing of the image being accomplished by the aid of a fluorescent screen. In general, however, the photo-micrographer has to work with an ordinary microscope and objectives, not even the advantage gained by the use of apochromats being available; and in such cases it will be of some interest to consider in what way the definition of his photographs may be improved. Now we are supposed to be dealing with objects which are so exceedingly minute that they approximate to points; but it is known that the image of a point is not represented as a point, but takes the form of a diffused disc of more or less appreciable size. Hence two dots, which may be separated by a very small interval, are each shown in the photograph surrounded by a circle of haze, which, by blocking up the space between the images, renders their differentiation most difficult and sometimes impossible. In the case of a single dot the haze surrounding it might not be objectionable, but in the case of two dots it causes them to appear as one elongated one, owing to the circles of confusion surrounding them. Now the diameter of these circles of confusion depends upon the wave-length of the light employed and the degree of magnification of the image; and the diameter may easily be calculated by taking the magnification as the numerator and the resolution as the denominator. Thus, suppose the magnification is equal to two thousand diameters, and that the resolution obtained by multiplying twice the wave-length per inch of the light employed by the N.A. of the objective is equal to 133·000, then the diameter of the circle of confusion would be equal to $\frac{2000}{133000}$, or a little over $\frac{1}{66}$ of an inch. Therefore, if two dots were sufficiently close together for the circle of confusion of one of them to be superimposed upon that of the other, the effect would be so to close up the interval between each dot as to prevent them from appearing as separate dots, and the result would give rise to a general fuzziness in the image. Now it is generally considered that for a photograph to appear sharply defined the circle of confusion must not exceed $\frac{1}{100}$ of an inch in diameter, and in the case of photo-micrographs it may with advantage be even less than this, as photographs of this nature are often examined with the aid of a hand magnifier. It is therefore obvious why photo-micrographs of very minute objects, seen under a magnification of two thousand diameters, often appear fuzzy or ill-defined when the circle of confusion is only $\frac{1}{66}$ of an inch in diameter, instead of $\frac{1}{100}$ of an inch or less. It has been suggested that an improvement would result by a lesser degree of magnification, but in dealing with very small objects a certain degree of magnification is necessary in order that the eye may be able to see the image distinctly. We must therefore try some other method of improvement. One which naturally suggests itself is to employ a slow plate, since the emulsion with which they are coated gives less difference of gradation than a fast one, and every photographer is aware that for copying black and white a slow plate gives better results than a rapid one. Another method which has been suggested consists in taking the negative on a rapid plate, because of the length of exposure necessary, and from this making a transparency on a lantern plate, or a plate such as the Ilford extra fine grain, or a process plate. From the transparency thus obtained a negative is then made by contact or otherwise on one of the same slow plates. This forms the printing negative, and prints made from such a one show the detail more clearly, any dots or markings standing out much more distinctly. This method of working, although it entails much more labour, quite repays one by the improvement in the photographs for the extra trouble taken in obtaining them, and it is quite worth anyone's while to try it. The writer has also found that a developer, such as hydroquinone, which has a great tendency to produce hard results, is very suitable for work of this kind. Whatever may be thought to the contrary, this method for improving the photographs is quite legitimate, since it merely removes false effects, which are due to the optical and photographic process.

PHYSICS.

By J. H. VINCENT, M.A., D.Sc., A.R.C.Sc.

MAGNETISATION BY ROTATION.—Various views have been put forward from time to time by mathematical physicists tending to show that rotation may lead to magnetisation. Experiments on the subject are exceedingly difficult, as the results, when positive, are usually found to decrease as experience is gained in the elimination of spurious effects. Writing in *Science* for July 30th, 1915, Barnett gives an account of experiments on the subject which yielded positive results. Two nearly similar rods of steel shafting were mounted with their axes horizontal and perpendicular to the magnetic meridian, and two similar coils of insulated wire were mounted about their centres. These oppositely wound coils were connected in series with a fluxmeter. One of the rods was rotated, and, after all suspected sources of systematic error had been eliminated, an effect was left corresponding precisely with a theory of the subject published by Barnett six years ago.

If these experiments successfully bear the brunt of criticism, they will have an important effect on the theory of terrestrial magnetism.

THE EFFECT OF AN ELECTROSTATIC FIELD ON SPECTRA.—In 1913 Stark discovered that, when certain spectrum lines are emitted in a strong electric field, they are markedly affected. A valuable critique on the work on this subject is given by Fulcher in *The Astrophysical Journal* for June, 1915. In order to examine the effects quantitatively, a field of about fifty thousand volts to the centimetre is required. As in the case of the Zeeman effect, the polarisation and number of components into which a line is split up by the field depend on whether we look along the field or at right angles to it. In a low-dispersion spectroscope the line H_α is, when observed at right angles

to the field, trebled; the two outer components are polarised along the field, while the central line is polarised at right angles. The effects become more complex as one passes from line to line in a series. The Hβ line splits into four components, Hγ into seven components, Hδ into eight components. The separation of the components is proportional to the field.

When examined in a direction along the field, the components are unpolarised, and occupy positions similar to those components in the first case, which are polarised at right angles to the field.

The effects observed in spectroscopes of great dispersive power are very much more complex; for example, Hδ is observed to have twenty-six components when viewed at right angles to the field.

SIR ARTHUR RÜCKER.—The death of Sir Arthur Rücker has removed a notable figure from English science. A Londoner by birth, he became the Principal of London University. He was born in Clapham in 1848, and, after a distinguished career at Oxford, became Professor of Physics at York College in 1874. He was Professor of Physics, Royal College of Science, London, 1886–1901, and Principal of the University of London, 1901–08. He was President of the British Association in 1902, and Secretary of the Royal Society, 1896–1901. As a physicist he will be remembered chiefly for his work on the thickness of soap films and for his researches in terrestrial magnetism. He was an excellent public speaker, and had an exceedingly engaging personality, which made him a successful educational administrator.

RADIO-ACTIVITY.

By ALEXANDER FLECK, B.Sc.

α RAYS IN HYDROGEN.—In the issue of "KNOWLEDGE" for November, 1914, attention was directed in this column to some experiments by Marsden by which he showed that, if an α particle—*i.e.*, a charged helium atom moving at high speed—came into contact with a hydrogen atom, the latter was able to acquire similar properties to those possessed by the α rays sent out by radio-active elements. These "H" particles, as they were called by their discoverer, could produce luminosity on a zinc sulphide screen. This phenomenon is usually ascribed to ionisation set up by some type of radiation. Some years ago C. T. R. Wilson devised an apparatus by means of which the path of a single α particle through air, saturated with vapour, could be photographed. This could be accomplished, because the particle in its passage through the air produced ions along its path, and on these ions vapour condensed into liquid. In the November issue of *The Philosophical Magazine* McLennan and Mercer describe how they attempted to apply Wilson's method to photograph the tracts of "H" particles. They did not succeed in doing this. If this failure is actually due to the fact that these "H" particles are not capable of producing ions, it follows that the interpretation of Marsden's experiment is not so simple as it formerly seemed to be.

LIFE-PERIOD OF THORIUM.—The period of average life of radio-active elements, of which the rate of change is very slow, has always been difficult to determine with any degree of accuracy. In the case of uranium several methods are available to arrive at independent results, and when the values given by these methods are in good agreement we can feel confident as to their accuracy. The case of thorium is, however, different, and so far only one method is available by which to estimate its rate of decay. This method consists in finding the total number of α particles sent out by one gramme of elemental thorium per second. The total number of atoms in that weight of thorium can easily be calculated, and we can thus get the fraction of thorium changing per second. From this value the period is directly calculated. The great difficulty, however, lies in the experimental measurement of the number of the particles emitted by the thorium. This is accomplished by electrical means, and it is necessary to use a fairly large weight of material to make the measurement; consequently there is an amount of absorption by the thorium itself of the α rays which is to a great extent unknown.

The previously accepted value, due to Geiger and Rutherford, is $1{\cdot}31 \times 10^{10}$ years, but recently Bertha Heimann (*Monatshefte für Chemie*, 1914, page 1533) has repeated the experiments, and gives a value, in all probability a more accurate one, of $1{\cdot}77 \times 10^{10}$ years as the time necessary for a quantity of thorium to decay to half-value.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

MEMORY OF HUMMING BIRDS.—Althea R. Sherman gives an interesting account of her experiments in feeding ruby-throated humming-birds (*Archilochus colubris*) from bottles of syrupy solution placed inside artificial flowers, or even without any floral disguise. The experiments were made in Iowa, and kept up for seven summers. About a teaspoonful of sugar was consumed by a bird in a day. Only the females came near the bottles. Several facts point to the conclusion that birds of former years return to be fed. Thus a humming-bird was seen thrusting its bill into the bottle on its first observed visit. On another occasion a newly arrived bird buzzed about the observer's head as do no other birds except those that have had experience of the feeding. "Two marvellously long journeys of from one to two thousand miles each had this small sprite taken since last she had drunk from the bottles, yet she had not forgotten them, nor the one that fed her. She was quite prone to remind either of us when the bottles were empty by flying about our heads, wherever she chanced to find us, whether in the yard or in the street."

FLOWERS AND THEIR INSECT VISITORS.—Lovell calls attention to cases of conspicuous flowers being rarely visited by insects. The introduction of odoriferous fruit juices led to visits from miscellaneous insects; the introduction of odourless syrup also induced numerous visits. Colours and forms are certainly perceived, but experience of the absence of food leads to conspicuous flowers being left alone. Odour makes a more powerful appeal than colour. The author has made a number of experiments, and comes to the interesting conclusion that "colours and odours attract the attention of insects; but bees in their visits to flowers, previously examined by them, are guided largely by the memory of past experience: they are able to associate different sense impressions, and unconsciously make analogous inferences." One has some difficulty in thinking of unconscious inferences; but the observed fact that disappointing experiences lead the insects to disregard the appeals of colour and odour is very interesting. It means an ability to profit by experience.

PROLONGATION OF LIFE.—Everyone recognises that there is great division of labour among the cells in the body of a higher animal. Many of them are very highly specialised, and it has been often suggested that it is this differentiation that makes death inevitable. The body is correlated, and its interdependence is such that a breakdown on the part of a few highly specialised nerve-cells, for instance, may be fatal to the life of the whole. Recent experiments on the life of cells and tissues removed from the body and kept in foreign or artificial environment, such as we have already considered in these notes, suggest that the tenacity of life on the part of highly specialised cells is greater than has been thought. Ganglion-cells in a higher animal do not increase in number after birth, and those of an adult animal cannot as yet be cultivated in artificial media; but it is premature to say that their complexity and sensitiveness necessarily involve death. Leo Loeb

has indeed recently suggested that the prolongation of life may, to a great extent, depend on forestalling the attacks of those injurious influences which are at present allowed to disturb the function of the nerve-cells.

GIANT GLOW-WORM.—Mr. E. Ernest Green exhibited to the Entomological Society of London specimens of the giant glow-worm of Ceylon (*Lamprophorus tenebrosus*) and its winged mate—a large fire-fly. Both sexes are brilliantly luminous. The colour of the light is emerald green. The larvae are as well illumined as the adults, and it is difficult to see the use of this. (The same difficulty occurs in the case of our British glow-worm where the larvae and the eggs are luminous.) If it be suggested that the luminescence of the large Ceylonese larva is like a warming colour, " the question occurs : Why should an insect that travels only in the dark require to call attention to its unpalatability ? " Mr. Green also points out that the winged male does not require to advertise his presence when seeking the wingless female. He has repeatedly observed that the male shut off his light when approaching a " calling " female.

STEGOSAURUS.—A fresh study of this extinct armoured Dinosaur from Jurassic strata has recently been made by C. W. Gilmore, of the U.S. National Museum. The weight of the living monster has been estimated at between seven and ten tons ; its length at about twenty feet ; its height to the top of the highest dorsal plate at about twelve feet. The exceedingly small and feeble teeth would appear to indicate that Stegosaurus fed upon very succulent plants. It probably frequented low, swampy regions. As Dollo first suggested, the type may have evolved from a bipedal ancestry. But " increasing bulk and development of the armour caused them to lose celerity of movement, and they became sluggish, slow-moving creatures of low mentality, only sufficient perhaps to direct the mere mechanical functions of life." In proportion to the size of the body, the brain cavity was more diminutive than in any other land vertebrate. The armour of the neck, back, and tail was formed by two rows of erect plates, the elements of one row alternating with those of another. The tail was a heavy stiff appendage incapable of more than cumbersome lateral movements, and wholly unsuited for use as a weapon against an active enemy.

CORRESPONDENCE.

THE GEGENSCHEIN.

To the Editors of " KNOWLEDGE."

SIRS,—I was lately asked by a correspondent to explain the Gegenschein. It was a light that I had not looked for, as I thought from its name that it was made in Germany ; but on examining printed records I found that it was an undoubted reality—a patch of light in the midnight sky—to which Messrs. Quénisset and Barnard had paid particular attention.

The following are the facts that distinguish this light. It is exactly opposite the Sun ; it is better seen when the air is not very clear ; its southern border is more defined than its northern border ; and it is not seen in June and December.

All these observations point to its connection with sunlight and the atmosphere alone. The action of the atmosphere in assisting the Gegenschein precludes all distant origin, for a slight haze obliterates the Zodiacal Light and the light of comets, and even the light of the Milky Way and of most of the stars, which all are brighter than the Gegenschein ; and its invariable position as regards the Sun precludes all meteoric origin, as that is in no way ruled by the Sun's direction.

Considering these facts, the answer that I gave to my friend was that the Gegenschein is the reflected light of the Sun from the twilight circle of atmosphere surrounding the Earth, and concentrated at the centre opposite the Sun.

The Gegenschein is best seen with hazy weather, as that best reflects the light : its border is less defined to the north, because there is less moisture in the air of the north to reflect the light than in the air of the south ; in midwinter it is not seen, as it approaches the Pole with want of vapour to reflect ; and at midsummer it is not seen, as there is too much reflected sunlight in the sky for it to be distinguishable.

W. F. BADGLEY.

DEVIZES.

REVIEWS.

FORESTRY.

The Preservation of Structural Timber.—By HOWARD F. WEISS, Director, Forest Products Laboratory, United States Forest Service. 312 pages. 9-in. ×6-in.

(McGraw-Hill Book Co. Price 12/6 net.)

" As long as a country is heavily timbered," writes the author, " conservative methods of utilising the timber will rarely be practised. This condition prevailed in the United States during its early history, but exists no longer. Scientific methods of managing forests, as well as efficient methods of utilising the timber cut from them, are now being practised. Both, however, are still in their infancy, but they are undergoing a rapid application."

Mr. Weiss defines his subject as " the art of protecting structural timber from deterioration by destructive agents," of which the more common " are decay, insects, marine-borers, mechanical abrasion, and fire." The practical importance of the matter to the United States may be gauged from his estimates that treatment with preservatives would effect a saving of fifty-eight per cent. of the sleepers now annually required for renewal, and that while, as a rule, not more than seventeen per cent. of planted trees are retained for the final timber crop, treatment would enable the eighty-three per cent. removed in successive thinnings to be put to more remunerative use than the fuel at which value alone they are now reckoned.

Mr. Weiss's official position has given him unrivalled opportunity for amassing at first hand a store of invaluable precise data on the subject, and he has produced a volume which may well be said to be indispensable to railway, mining, electrical and municipal engineers, and lumber merchants in America, and to be of very great use to their fellows in other continents. He begins with an interesting historical sketch from the unprocessed wood preserved in ancient Egyptian entombments by the exceptional condition of dryness, the use of olive and cedar oils as antiseptics by Greeks and Romans, and the charring of prehistoric piles to the many impregnation processes of modern times. The ravages of the ship-worm were, it seems, familiar to the ancient Romans, and the use of lead sheathing is on record in the reign of Henry VI. The author rightly insists on the fungal origin of decay, as against Liebig's purely chemical theory of eremacausis ; and he gives brief accounts of the destruction caused by beetles, ship-worms, woodpeckers, and so on. He even devotes a chapter to such substitutes for timber as concrete posts and iron

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railway sleepers and telegraph poles; but his main subject is the preservation of timber by impregnation processes. Two most practical chapters are devoted to the structure of wood in so far as it affects impregnation, and to seasoning as preparatory to treatment. It was the author who, in association with H. D. Tiemann, showed in 1911 that the cell-walls of wood frequently slit open during drying.

Treatment processes are classified as "superficial," such as charring, brush treatment and dipping, and impregnation, and these latter into non-pressure and pressure processes. Among the chief preservatives discussed as in use in the United States are copper sulphate (Margary or Boucherie's processes), mercuric chloride (Kyanising), zinc chloride (Burnettising), the various creosote processes, and the more recent sodium fluoride. Eminently practical details are given of the construction and cost of the plant for the different systems, and then special chapters are devoted to "cross-ties" (*i.e.*, sleepers), poles and cross-arms (for telegraphic purposes), fence posts, piles, and boat timbers, mine props, paving blocks, shingles, and "lumber" (*i.e.*, building timber). A chapter is given to the question of fire-proofing timber and another to the effects of processing upon the strength and electrical resistance (miscalled "electrolysis") of wood. Many minor processes are briefly described in an appendix, and a full list of United States patents dealing with the subject is given.

What is at once the strength and the weakness of the work is its exclusively American character. Hardly any species of timber trees are mentioned save those indigenous to the United States, nor is much account given of methods not in use in that country. This, of course, means that the author's facts are those verified by his own experience; but if the various trustworthy investigations which have of late years been carried out in India, Australia, and France could have been incorporated, his book would have become a standard work for other lands than his own.

G. S. BOULGER.

METEOROLOGY.

British Rainfall, 1914.—By HUGH ROBERT MILL, Director, and CARLE SALTER, Assistant Director of the British Rainfall Organization. 92 + 356 pages. Maps and illustrations. 8½-in. × 6-in.

(Edward Stanford. Price 10/-.)

This is the fifty-fourth annual volume of this valuable and useful publication, which deals with the distribution of rain in space and time over the British Isles. The present volume differs in appearance from its predecessors by being slightly wider and thinner. The extra width has enabled the general table of annual rainfall to be extended by the addition of a column, giving the total for the year in millimetres as well as in inches. This has been done to enable anyone to whom millimetres are more familiar than inches to utilise all the annual data. The extra half an inch in the width of the page has made the book more attractive in appearance and much easier to handle.

The work is divided into three parts. Part I contains the report of the Director to the Trustees of the British Rainfall Organization and three special articles, namely, (1) isomeric rainfall maps of the British Isles; (2) the thunderstorm of June 14th, 1914; and (3) the rain-fields of the thunderstorm of June 14th, 1914, by J. Fairgrieve. Part II is devoted to observers' notes and special discussions on the monthly and seasonal rainfall. Part III, which occupies one hundred and sixty-two pages, contains the general table of total rainfall in 1914 at five thousand four hundred and fifty-three stations, or eighty-three more than in the previous year.

In dealing with the extremes of rainfall in 1914 Mr. Salter says: "Over the British Isles, as a whole, it is not possible to decide whether the wettest spot was round the Stye, in Cumberland, or in Snowdonia, in both of which places little short of two hundred inches fell. The driest part of the country was probably round Shoeburyness, where the total fall was between nineteen and twenty inches."

W. MARRIOTT.

PHOTO-MICROGRAPHY.

Elementary Photo-micrography.—By WALTER BAGSHAW. Third edition. 140 pages. 57 illustrations. 7¼-in. × 4¾-in.

(Iliffe & Sons. Price 2/6 net.)

In this book, which has now reached its third edition, the author deals with his subject in a manner which is so clear, and at the same time so free from unnecessary technical details, that any worker with a microscope who possesses a knowledge of photography may be able, with a little practice, to make good photo-micrographs of any objects of which he may desire to obtain permanent records. The chief merit of the book consists in its simplicity of style; and, although it is of an elementary nature, there is a good deal that will interest even the more advanced student. The illustrations are excellent, and serve to show what good results may be obtained from, in many cases, difficult objects.

E. S.

NOTICES.

THE PHOTOGRAPHIC SURVEY OF SURREY.—We learn from the report of the Council of the Photographic Survey of Surrey that three hundred and ten prints have been added to the collection during the year, and that the totals which have now been brought together are seven thousand one hundred and fifteen prints and one thousand four hundred and ninety-two lantern slides.

THE GEOLOGY OF LYMINGTON AND PORTSMOUTH.—The Board of Agriculture and Fisheries desires to give notice of the publication of a Geological Memoir of the country near Lymington and Portsmouth, price 1s. 6d. The area described consists principally of Tertiary beds with wide spreads of plateau-gravel and alluvial deposits. Copies may be obtained through any bookseller, from Mr. T. Fisher Unwin, 1, Adelphi Terrace, London, W.C.; or from the Director-General, Ordnance Survey, Southampton.

THE "WELLCOME" PHOTOGRAPHIC "EXPOSURE RECORD AND DIARY."—Once again we have received the "Exposure Record and Diary" which Messrs. Burroughs Wellcome & Company issue annually. Incidentally, it contains a great deal of information, and it is certain that every photographer will find something of use to him in the little volume.

THE HISTORY OF KEW GARDENS.—We have received a very interesting account of the connection of Kew with the history of botany, written by Professor G. S. Boulger. The story begins with William Turner, who died in 1568, who mentions "his Lordes gardine at Shene," as well as those at Syon, and speaks of his owr garden at Kew. An account of many other worthies, including Sir Henry Capel, John Stuart, Earl of Bute, the Rev. Stephen Hales, Sir Joseph Banks, carries on the tale, and brings us down to the Hookers, Sir William Thiselton-Dyer, and the present Director, Sir David Prain.

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